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Optimized lidar scanning patterns for reduced project uncertainty

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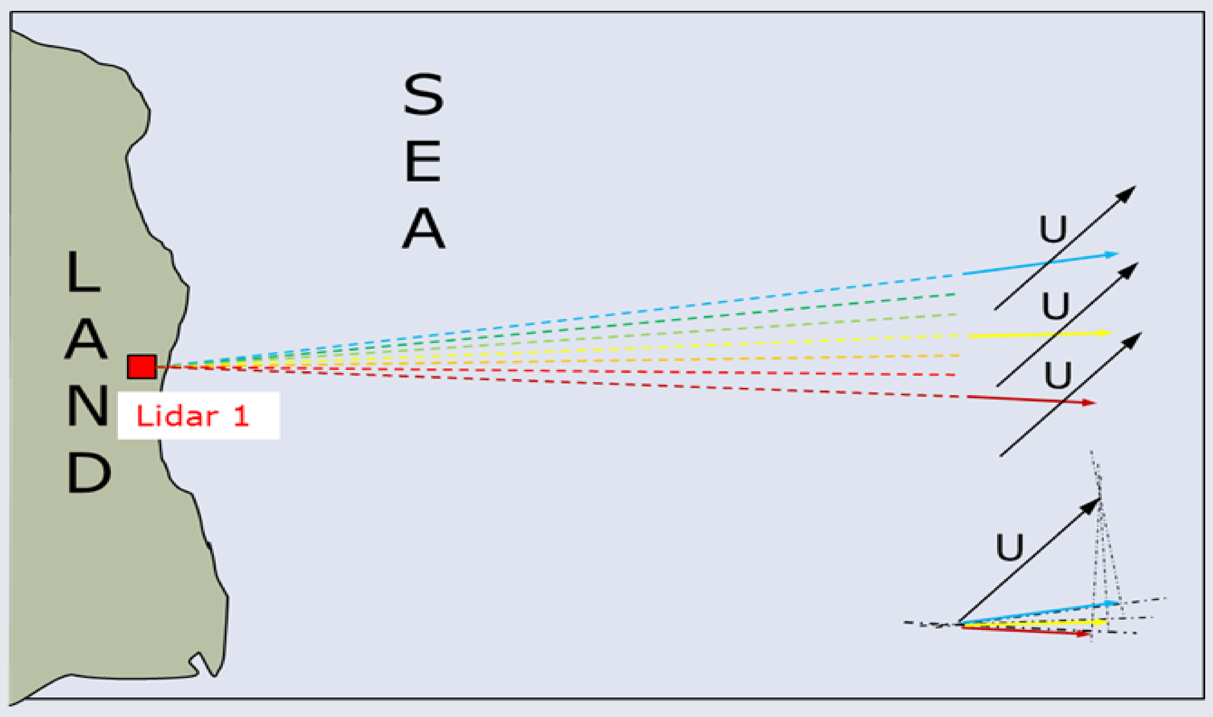
Introduction

Measuring accurate wind speed and direction are crucial for planning new wind energy projects, as they are the fundamental inputs for the evaluation of the potential energy yield of wind farms. Advances in scanning lidars have resulted in systems with longer range, durability and accuracy. These devices are now realistic and attractive tools for measuring the wind resource in reasonably homogeneous areas where a good vantage point is available, for example a cliff-top lidar measuring the wind resource in the near-coastal waters.

The lidar measures the radial wind speed at the required range over a range of azimuth angles. The principle of the measurement is that each of the beam angles measures a **different** projection of the **same** horizontal wind speed:



A scanning lidar has the advantage that its beams can be steered arbitrarily. Instead of measuring the wind speed at just one point, a scanning lidar can measure at a number of positions, giving valuable information about the spatial variability of the wind resource at a potential wind farm site. When the beam is required to visit multiple sites, the frequency of measurements at any one point is of course reduced. In this poster, we investigate how the wind speed uncertainty at a single point (accuracy and scatter) depends on the duty-cycle of the measurements.

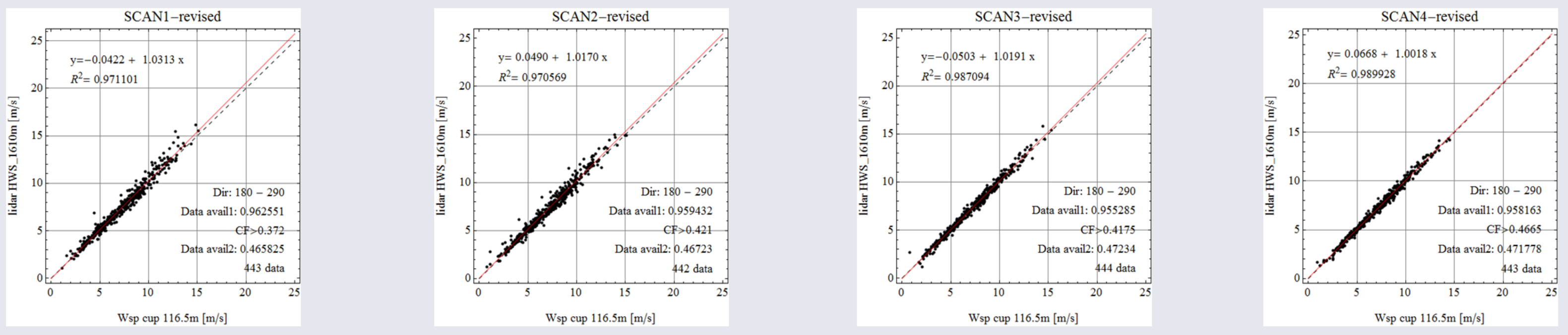
Method

Results from a WINDCUBE 200S (6.5km measurement range scanning lidar) deployed at the Danish Technical University (DTU), for a period of two months, are presented in this poster. The lidar was positioned 1.5km from an on-shore mast (the Høvsøre met mast) and sector-scanning measurements performed with the beams sweeping to coincide with the top of the mast (116m). Different sector widths and scanning speeds were investigated Various scanning strategies were performed to test the accuracy of the wind speed retrievals.

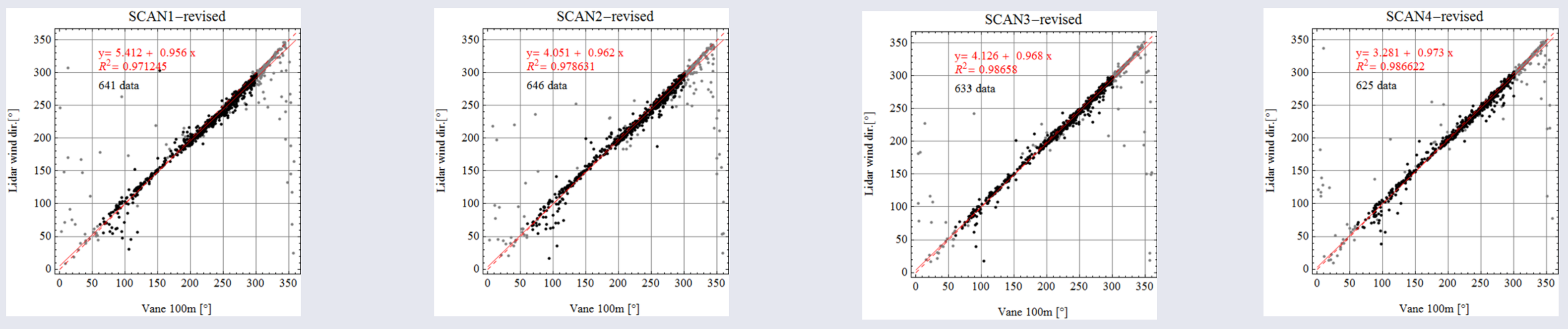
In a second phase, the lidar performed sector-scans at several heights in order to assess the ability of the system to measure wind shear.

Results

Horizontal wind speeds and wind directions were derived by Leosphere from the raw lidar measurements. The results shown here are for a second version of the processing algorithm after it had been revised using the mast data. These processed result were compared to the mast measurements. First we looked at results using different sector widths and scanning speeds:

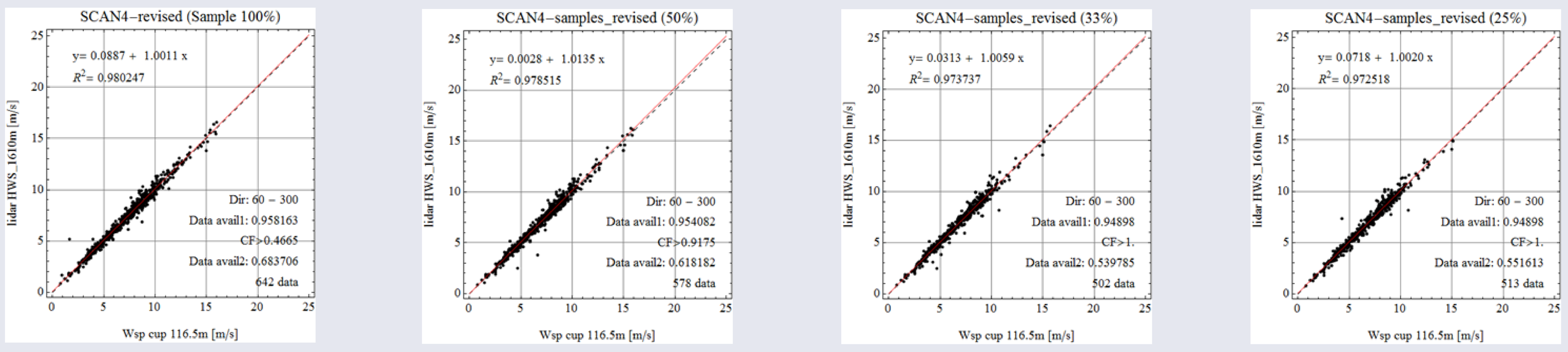


30° sector, 2°/s | 30° sector, 3°/s | 45° sector, 2°/s | 45° sector, 3°/s



From these results we concluded, considering both the speed and direction results, that the 45°sector with a 3°/sec scanning speed (SCAN4) gave the best overall performance.

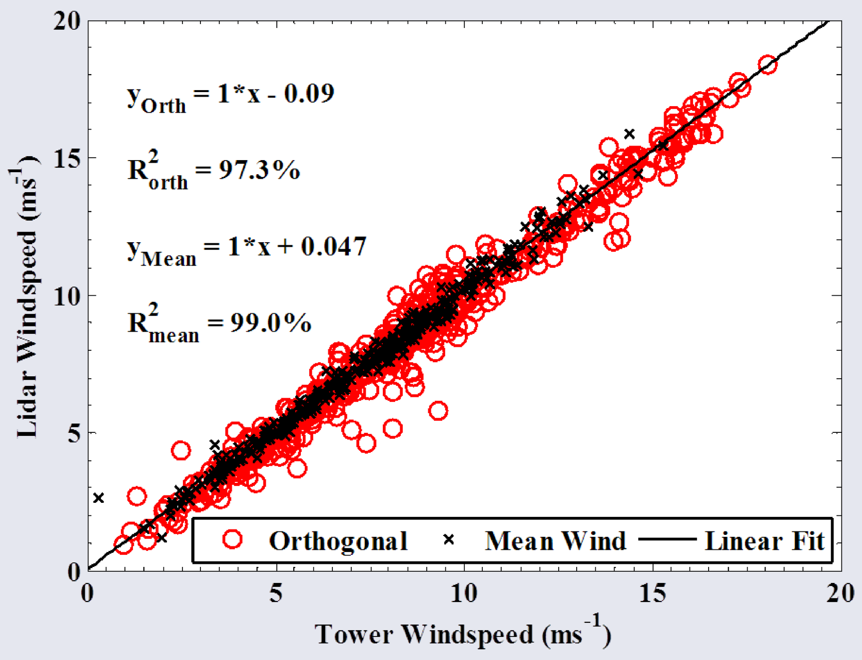
These first results represents the measurement performance available scanning only at one position. If instead, the scanning lidar is used to give some information about the spatial variation, the duty-cycle at any one point will be reduced. The following results show the degradation due to this effect:



100% duty-cycle | 50% duty-cycle | 33% duty-cycle | 25% duty-cycle

The degradation is seen to be only marginal although the different numbers of data points in each plot somewhat confuses the comparison.

An inherent weakness of a sector-scanning algorithm is the difficulty in reconstructing the wind speed when the wind direction is perpendicular to the sector direction. This plot shows that the scatter in orthogonal (±45°) wind directions is significantly larger than for parallel (±45°) directions although no significant bias is introduced.



Conclusions

A sector-scanning lidar, simulating near-shore measurements from an on-shore vantage point, has been tested at an on-shore site. Various scanning strategies have been tested and from these, a 45° sector width with a 3° /sec scanning speed found to be best. Measurement performance is generally acceptable although significant scatter (but no significant bias) was observed for wind directions perpendicular to the scanning centre direction. It was also shown that the measurement performance was not significantly degraded when simulating scanning at multiple measuring locations.

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